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Prenatal Seasonality, Child Growth, and Schooling Investments

Evidence from Rural Indonesia

Futoshi Yamauchi

Poverty, Health, and Nutrition Division

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

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AUTHOR

Futoshi Yamauchi, International Food Policy Research Institute
Senior Research Fellow, Poverty, Health, and Nutrition Division

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ABSTRACT

This paper examines the impacts of prenatal conditions on child growth using recent data from Indonesia. There is seasonality in birth weight: this measure is significantly higher during the dry season than during the rainy season. The empirical results show that an increase in birth weight improves child growth outcomes as measured by the height and weight Z-scores, as well as schooling performance as measured by age at start of schooling and number of grades repeated. The interactions of ecological variations affect early childhood human capital formation and can have long-term impacts on children's outcomes.

Keywords: birth weight, child growth, schooling, Indonesia

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1. INTRODUCTION

In developing countries, ecological and human factors often interactively determine the environment in which children grow (Ulijaszek and Strickland 1993). Seasonality in rainfall patterns can affect the production cycle, potentially creating fluctuations in nutrition intake (see, for example, Behrman, Foster, and Rosenzweig 1997; Paxson 1993) and therefore child growth. This paper demonstrates that there is seasonality in birth weight in rural Indonesia and shows that variations in birth weight cause variations in child growth over time and in schooling investments at a later stage of life.

Seasonality in consumption patterns can influence maternal nutrition intake, affecting prenatal development and subsequent birth outcomes (see, for example, Rayco-Solon, Fulford, and Prentice 2005a; Kramer 2003; Neggers and Goldenberg 2003).[1] Low birth weight is caused by conditions such as prematurity and intrauterine growth retardation, and insufficient nutritional intake during pregnancy increases the likelihood of intrauterine growth retardation (see, for example, Ceesay et al. 1997; Moore, Collinson, and Prentice 2001; Moore et al. 2004; Verhoeff et al. 2001; Ramakrishnan 2004; Lunde et al. 2007; Kaestel et al. 2005; Rayco-Solon, Fulford, and Prentice 2005b).[2]

As Alderman and Behrman (2006) summarized, low birth weight is an important factor in increasing infant mortality and critically affects cognitive and physical growth. The authors showed that reducing the incidence of low birth weight created significant economic returns. However, caution should be taken when seeking to forge causal connections between birth weight, or prenatal conditions and child growth and adult outcomes. For example, many factors that affect prenatal conditions (for example, household income) also directly influence the determinants of child growth. Notwithstanding that, Behrman and Rosenzweig (2004); Black, Devereux, and Salvanes (2007); Buckles and Hungerman (2008); and Plug (2001) all demonstrated the causal effects of birth weight on later outcomes. Furthermore, several studies have examined the effects of environmental factors such as rainfall and wildfires experienced during gestation and early childhood on human capital outcomes (Godoy et al. 2008; Jayachandran 2005; Maccini and Yang 2009).

Although the findings here are not directly linked to rainfall amounts, it is noteworthy that food availability may differ between rainy (hunger) and dry (food security) seasons (Herdt 1989), leading to seasonal differences in birth weight (see, for example, Rao et al. 2009; Simondon et al. 2004; Rayco-Solon, Fulford, and Prentice 2005b). Lokshin and Radyakin (2008), in a sample of data from India, found significant seasonality in the anthropometric measures of children, and further showed that the differences were statistically attributable to birth month.

Nutrition-related seasonality doesn't arise just from environmental and market conditions; it may also be grounded in societal norms. The majority of the population in Indonesia is Muslims, who fast during a certain period each year (Ramadan). In principle, pregnant women are exempt from this practice. However, because food consumption is not perfectly distinguishable among household members, who are likely to share the pot, a pregnant woman's nutritional intake may be negatively affected by the fasting of other family members. Accordingly, this study examines whether the birth weights of children born during or soon after Ramadan differ from those of children born during the remainder of the year. To identify this effect, the analysis made use of exogenous between-province differences in religion: the

[1] If this cyclical effect can be predicted, it could enable agents to choose fertilization timing to separate childbirth outcomes from the seasonality effects. However, there does not appear to be a pattern in the number of births by month in the sample, suggesting that the studied population does not choose fertilization timing to maximize birth outcomes (assuming that the gestation period does not vary).

[2] It is reported that the likelihood of premature births is the same in developed and developing countries.

majority of people in North Sulawesi are Christian, and the other provinces in the sample are predominantly Muslim.[3]

However, a limitation of this paper is the fact that the determinants of the birth weight seasonality are not identified. In other words, seasonality is treated as the determinant of birth weight in the following analysis.

The findings on the impacts of prenatal seasonality on early-stage child growth and schooling investments in Indonesia are directly linked to an emerging body of literature on the long-term impacts of early childhood investments on subsequent human capital and labor market outcomes (for example, Alderman, Hoddinott, and Kinsey 2006; Hoddinott et al. 2008; Yamauchi 2008).[4] These studies show that early childhood growth, which is typically measured using the height-for-age Z-score, has long-term impacts on human capital formation, as measured by schooling attainment and labor market outcomes. Malnutrition during early childhood has increasingly been shown to adversely affect child growth at later stages.[5] Therefore, prenatal conditions and social norms that influence early childhood growth and health can also have potentially long-term impacts on the inequality in human capital among children born in different seasons.

This paper is organized as follows. The next section discusses the econometric framework utilized in the analysis. Section 3 describes the survey data from Indonesian villages, and Section 4 presents the empirical results on birth weight seasonality and its impacts on child growth and schooling investments. The evidence shows that birth weight has significant seasonality, with its peak in the dry season of Indonesia. Moreover, increasing birth weight significantly improves child growth and schooling outcomes.

[3] However, it is not possible to completely distinguish seasonality caused by production cycles from that caused by social norms, as, again, the two are correlated. Differences in the timing of the rainy season among provinces result in different crop seasons. The rainy season may start October, November, or December, beginning earlier in the eastern provinces. Therefore, one must be cautious when interpreting differences between the Muslim-majority and Christian-majority provinces, because their production cycles are inherently different.

[4] See Stechel (2009) for a recent review of heights and human welfare.

[5] The literature on consumption smoothing in the developing-country context has largely focused on the welfare implications of income fluctuation and consumption-smoothing mechanisms (for example, Townsend 1994; Ligon and Schechter 2003). Some empirical studies have shown that income shock affects nutrition intake among children at the early stage, and therefore has long-term impacts on human capital formation (for example, Alderman, Hoddinott, and Kinsey 2006; Hoddinott and Kinsey 2001).

2. ECONOMETRIC METHOD

The analysis uses a two-stage approach: first, the seasonality effects of birth weight discussed earlier are examined, and then child growth is estimated by instrumenting birth weight. The birth weight equation is written as follows:

$$w_{ij} = \alpha_1 + Z_{ij}\gamma + \varepsilon_{ij}, \tag{1}$$

where w_i is an input for the growth, such as the (log of the) birth weight, of child i in household j; Z_{ij} is a set of variables that captures exogenous factors, such as natural/human seasonality, and that affect w_{ij}, but do not directly affect child growth or schooling outcomes; and ε_{ij} is an error term. Z_{ij} also incorporates a gender dummy, birth year, and village-fixed effects.

In the second stage, child growth is estimated with the equation:

$$h_{ijt} = \alpha_2 + w_{ijt}\beta + X_{ijt}\delta + \nu_{ijt}, \tag{2}$$

where h_{ijt} is a child anthropometry measure and schooling outcomes; X_{ijt} includes a gender dummy, age in months, birth year, and village-fixed effects; and ν_{ijt} is an error term. The controls in equations (1) and (2) vary, depending on whether the analysis concerns the effects of birth weight seasonality on child growth or on schooling outcomes.

In the analysis of birth weight's effects on anthropometry and schooling outcomes, we can instrument birth weight under the condition that birth month is uncorrelated with ν_{ijt}. Since birth month approximately indicates fertilization month, this condition means that the decision on (and occurrence of) fertilization and the likelihood of prematurity are not correlated with unobserved components of child growth occurring after nine months from the time of fertilization.[6] Furthermore, the birth month may correlate with sanitation conditions that could affect the likelihood of a child becoming infected with a disease that affects growth. Although this study lacked the means to directly address this potential causality, the preliminary analysis found no evidence that birth month was significantly associated with the pertinent child growth measures, such as height-for-age Z-score.

Notably, birth weight could affect the infant mortality rate, creating a potential selectivity bias in the estimates. The importance of this issue depends on the empirical setting. Unfortunately, there are no birth weight data for those infants who died, so this issue cannot be examined here. However, a preliminary analysis showed that the number of births did not follow a seasonal pattern in the sample (see Table 2.1), which implies that infant mortality does not have significant seasonality.

Table 2.1—Birth month summary

Birth month	Frequency	Percent
1	148	6.20
2	173	7.24
3	224	9.38
4	207	8.66
5	230	9.63
6	188	7.87
7	218	9.13
8	207	8.66
9	184	7.70
10	198	8.29
11	214	8.96
12	198	8.29
Total	2,389	100.00

Source: IMDG–2 (2010).
Note: Sample consists of children age 0 to 12 years.

[6] Variations in lactation period are less important than nutritional variations in determining birth outcomes.

3. DATA

The data come primarily from village- and household-level surveys conducted in 2007 and 2010, covering 98 villages in seven provinces (Lumpong, Central Java, East Java, West Nusa Tenggara, South Sulawesi, North Sulawesi, and South Kalimantan) as part of the Japan Bank for International Cooperation Study of Effects of Infrastructure on Indonesia Millennium Development Goals (IMDG). The 2007 village survey reported the physical and economic distances from the village to various economic activity points, such as markets, stations, and capital towns.

The survey sample was designed to overlap with villages covered in the 1994/95 PATANAS survey conducted by the Indonesia Center for Agriculture and Socio Economic Policy Studies to build household panel data. The PATANAS survey focused on agricultural production activities in 48 villages chosen from different agroclimatic zones in these seven provinces. In 2007 the IMDG project expanded the scope of research by means of a general household survey, and the research was further expanded with the surveying of 51 additional villages in the seven provinces.

In the sample of previously surveyed villages, we resampled 20 households per village, and the split households were followed. In the new villages, the sample included 24 households from the two main hamlets in each village. One of the 48 villages included in the 1994/95 PATANAS survey (in West Nusa Tenggara Province) was not accessible in 2007 because of safety concerns, so the overall sample consisted of 98 villages. The locations of the sampled villages are shown in Figure 3.1.

Figure 3.1—Locations of survey villages

Source: Author.

In 2010 a follow-up survey covered all 98 villages. The 2010 survey had a few important changes in the design. First, it tracked out-migrants in terms of either physical visits or phone calls (in addition to capturing split households in the same villages). Second, the anthropometry module covered children age 0 to 12 years, so the coverage of children was expanded (the 2007 survey covered children age 0 to 60 months).

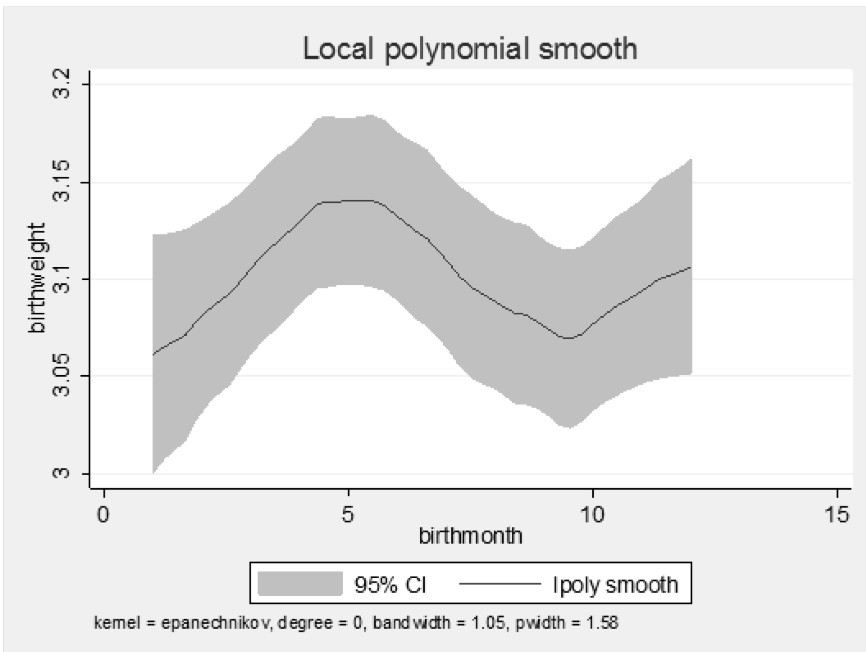
This study uses the anthropometry section of the 2010 survey. Therefore, the sample size is almost double that of the 2007 survey. In addition to children born in 2007–2010, the analysis includes those born in 1997–2002. The survey round included a child anthropometry module, in which the current height, current weight, and birth weight were recorded for children age 0–12 years.

4. BIRTH WEIGHT SEASONALITY AND ITS IMPACTS ON CHILD GROWTH

Observations

Figure 4.1 shows the relationship between birth month and birth weight. It is interesting to note that (1) there is a peak in the middle of the year (from May to August), which corresponds to the dry season in many parts of the country, and (2) there is a drop between September and November. Given the possibility of a lag in the effect of consumption on birth weight, this cycle could be caused by production seasonality.

Figure 4.1—Seasonality in birth weight



Source: IMDG–2 (2010).
Note: CI = confidence interval.

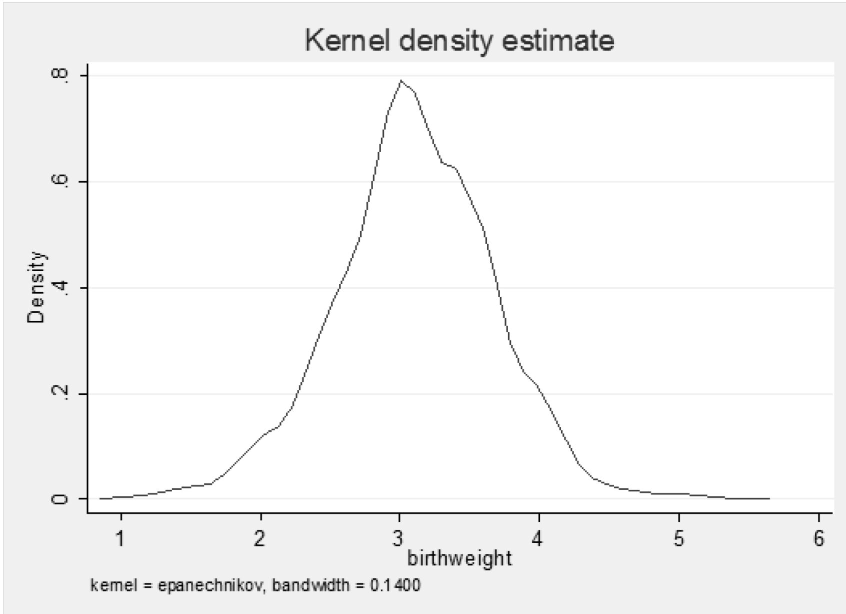
Herdt (1989) reported that the Indonesian rice harvest is concentrated in the period of April to June, which suggests that rice is most available after May. The seasonal fluctuations of birth weight in Figure 4.1 are largely consistent with the seasonal fluctuations in rice supply.

The above graph suggests that birth weight, which is affected by seasonality and social norms, has impacts on early childhood growth and long-run human capital formation. In other words, seasonality or social norm effects (differentiated by province) can be used as determinants of birth weight in equation (2) and thereby reveal the effects of birth weight on child growth.

Because the child anthropometry data pertain only to those who were alive at the time of survey, the birth weights of children who died are unavailable to control for sample selection caused by infant mortality related to low birth weight. This issue can be particularly important in a high-mortality environment (see, for example, Lee, Rosenzweig, and Pitt 1997).

The empirical findings point to rapid improvements in both infant and child mortality since the 1990s. Although it is not possible to rule out a potential correlation between infant/child mortality and birth weight that creates selectivity, Figure 4.2, the distribution of birth weight, does not show any truncations, indicating that mortality due to low birth weight is not significant in the sample.

Figure 4.2—Birth weight density



Source: IMDG–2 (2010).

Another concern is the potential correlation between birth month and the incidence of infant mortality, which could also bias the estimates. Table 2.1 shows the number of living children less than 12 years of age by birth month. No significant pattern is apparent here. The constant number of births across months indicates that infant mortality is not systematically correlated with birth month, eliminating this as a possible source of bias in relation to birth month.

The next issue that may affect the empirical results is potential selectivity associated with the endogeneity of birth weight records. Birth weight is most likely to be recorded if the delivery takes place at a healthcare facility or is attended by a midwife, and the mother has a mother-child handbook. Therefore, it is reasonable that the likelihood of birth weights being recorded varies across villages.

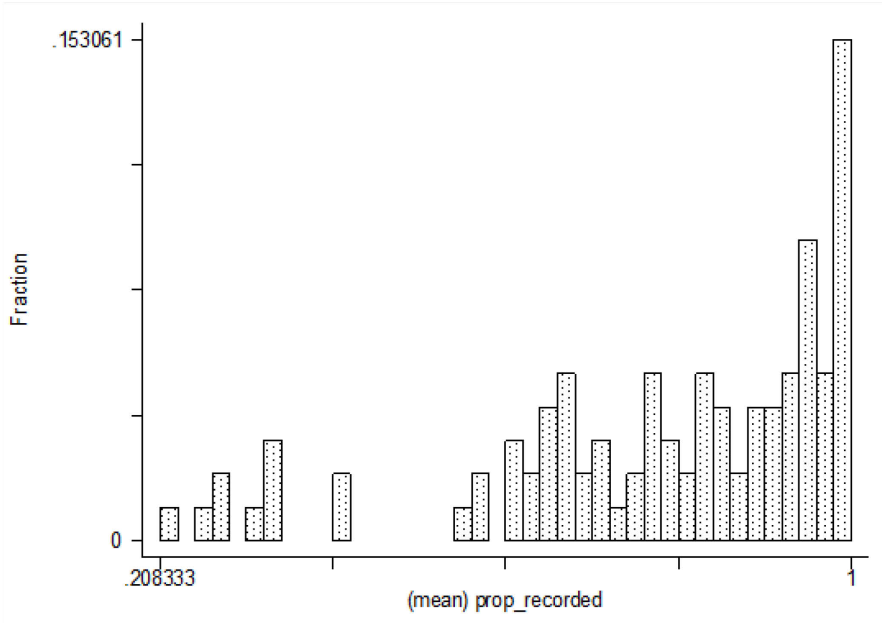
Figure 4.3 shows the distribution of the proportion of birth weight records out of all births (child alive now). Some villages had few records out of all births, though many villages tended to record birth weight.

Table 4.1 displays the relationship between birth year and the likelihood of birth weight being recorded. The table clearly shows that the likelihood increased monotonically over time. Therefore, more recent births are more likely to have birth weight records. Table 4.2 presents data on birth month and the likelihood of birth weight being recorded. Some fluctuations over months are present, but the variations seem insignificant.

The last column in Table 4.2 shows linear probability model estimates, which confirm the preceding observations. Birth month effects on the likelihood of birth weight being recorded are insignificant. Therefore, the likelihood of birth weight being recorded is correlated with birth year and village, but not with birth month. The following analysis of birth weight seasonality uses the sample of villages where birth weights were most likely to be recorded.

Using the sample of villages where the proportion of birth weights recorded was greater than 80 percent (to minimize the effect of birth record selectivity), Figure 4.4 shows the seasonal pattern of birth weight. The figure confirms the robustness of the observations in Figure 4.1, implying that the seasonality is not affected by the selectivity of birth weight records.

Figure 4.3—Proportion of birth weights recorded, by village



Source: IMDG–2 (2010).
Note: The sample consists of 98 villages.

Table 4.1—Birth weight recorded, by year of birth (frequencies and percentages)

	Recorded?					
	No		Yes			
Year	Number	Percent	Number	Percent	Total	Percent
1997	33	36.67	57	63.33	90	100.00
1998	57	34.34	109	65.66	166	100.00
1999	55	29.41	132	70.59	187	100.00
2000	73	33.80	143	66.20	216	100.00
2001	52	25.24	154	74.76	206	100.00
2002	58	30.05	135	69.95	193	100.00
2003	56	26.92	152	73.08	208	100.00
2004	41	23.16	136	76.84	177	100.00
2005	30	16.95	147	83.05	177	100.00
2006	39	20.10	155	79.90	194	100.00
2007	41	23.56	133	76.44	174	100.00
2008	30	14.93	171	85.07	201	100.00
2009	32	16.49	162	83.51	194	100.00
2010	9	10.23	79	89.77	88	100.00
Total	606	24.52	1,865	75.48	2,471	100.00

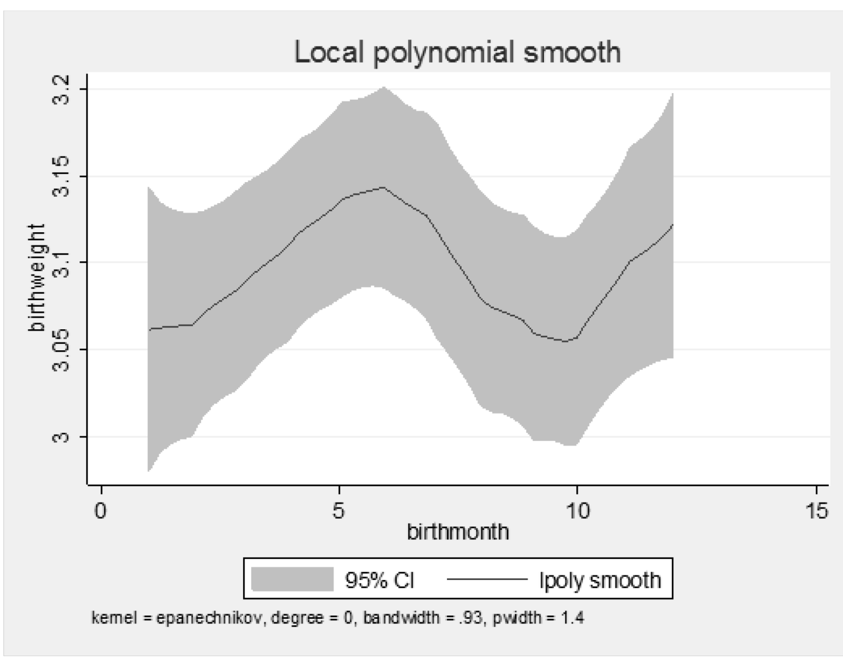
Source: IMDG-2 (2010).

Table 4.2—Birth weight recorded, by month born (frequencies and percentages)

	Recorded?							
	No		Yes					
Year	Number	Percent	Number	Percent	Total	Percent	Regression	
1	36	24.32	112	75.68	148	100.00	Omitted	
2	38	21.97	135	78.03	173	100.00	0.0281	(0.43)
3	61	27.23	163	72.77	224	100.00	-0.0739	(1.29)
4	42	20.29	165	79.71	207	100.00	-0.0121	(0.20)
5	50	21.74	180	78.26	230	100.00	0.0038	(0.06)
6	35	18.62	153	81.38	188	100.00	0.0775	(1.18)
7	51	23.39	167	76.61	218	100.00	0.0442	(0.73)
8	50	24.15	157	75.85	207	100.00	0.0211	(0.33)
9	42	22.83	142	77.17	184	100.00	0.0157	(0.24)
10	38	19.19	160	80.81	198	100.00	0.0648	(1.00)
11	47	21.96	167	78.04	214	100.00	0.0680	(1.09)
12	60	30.30	138	69.70	198	100.00	-0.0414	(0.64)
Total	550	23.02	1,839	76.98	2,389	100.00		
R-square								0.5733
Number of observations								2,299

Source: IMDG-2 (2010).
Note: Regression shows linear probability model estimates with robust standard errors using village clusters (controlling village dummies, birth year dummies, and their interactions).

Figure 4.4—Seasonality in birth weight for villages with the proportion of birth weights recorded greater than 0.8



Source: IMDG-1 (2010).
Note: CI = confidence interval.

It should be noted that although the findings indicate significant seasonality in birth weight, it is difficult to identify factors explaining the seasonality, such as natural production cycles and influences related to social norms. Indonesia and the sample both exhibit heterogeneity in agroclimatic and socioeconomic conditions. Yamauchi, Sumaryanto, and Dewina (2009) reported from the 2007 survey that rainfall patterns differ between Sulawesi and the Lampong, Java, and West Nusa Tenggara regions. The type of crop production also differs between the regions. Therefore, the present analysis is not sufficient to identify the specific factors behind the observed seasonality of birth weight.

Birth Weight Seasonality and Child Growth

This section summarizes the empirical results on birth weight seasonality and its impact on child growth. Table 4.3 shows the determinants of birth weight.

Table 4.3—Birth weight data

Dependent: Birth weight: age 0-12 years

	(1)	(2)	(3)
	Proportion of birth weights recorded		
Months/seasons	**> 0.8**	**> 0.8**	**> 0.8**
February	0.0031	0.0370	
	(0.03)	(0.26)	
March	0.0953	0.0268	
	(0.84)	(0.21)	
April	0.1644	0.1717	
	(1.45)	(1.38)	
May	0.1813	0.1544	
	(1.53)	(1.18)	
June	0.3025	0.2908	
	(2.36)	(2.08)	
July	0.1775	0.1757	
	(1.44)	(1.27)	
August	0.2076	0.2251	
	(1.70)	(1.65)	
September	0.1291	0.0514	
	(1.04)	(0.38)	
October	0.1408	0.1392	
	(1.19)	(1.03)	
November	0.0705	-0.0134	
	(0.61)	(0.10)	
December	0.2729	0.3361	
	(2.29)	(2.44)	
May–August			0.1425
			(2.14)
September-December			0.0601
			(0.89)
Village dummies	Yes	Yes	Yes
Birth year dummies	Yes	Yes	Yes
Birth year dummies * village dummies	Yes	Yes	Yes
R-square	0.5712	0.5528	0.5405
Number of observations	1,782	1,152	1,152

Source: IMDG-2 (2010).
Notes: Numbers in parentheses are absolute t-values using robust standard errors. Observations from 1997 were not included in the estimation (1998 = omitted baseline). The specifications include village dummies and the interactions of birth year and village dummies.

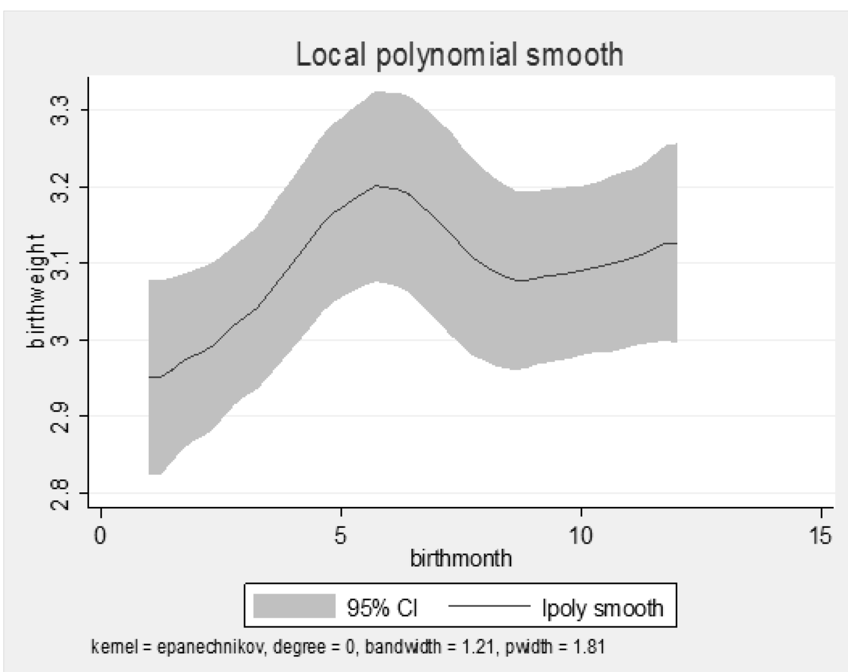
Column 1 shows the effects of birth month on birth weight. The specification includes village-specific birth year dummies to control for village-specific weather shocks. As indicated in Figures 4.1 and 4.4, birth weight is highest around June, with the low point occurring in October and November. Birth weight increases in December, but the beginning of the calendar year shows lower birth weight. The birth weight result for December looks highly idiosyncratic, whereas the large birth weight figure observed in the period of April to August is cyclical and roughly coincides with the major harvest season in Indonesia.

Column 2 uses the sample of villages where the proportion of births with birth weight records is more than 80 percent. By using the sample of villages that are likely to report birth weight, the potential selectivity related to endogenous birth weight records can be controlled. As Figure 4.3 indicates, the proportion of birth weight recording varies across villages. The results in this column are quite similar to those of column 1, which confirms that the selectivity of birth weight recording does not cause the observed seasonality.

Column 3 uses season indicators that divide the year into three periods based on the crop production seasons: January–April, May–August, and September–December (the period of January–April is omitted here). This estimation uses the sample of villages where the proportion of birth weight records was higher than 80 percent. The estimation controls for birth year and village-fixed effects. The results show significant positive effects for May–August and September–December. This finding is consistent with the pattern shown in Figure 4.1, where a peak in (log) birth weight appears during May–August.

The difference in the religion of the majority between North Sulawesi and the other provinces in the sample was used to investigate whether religious practice influences the birth weight seasonality. North Sulawesi is known as a Christian majority province, whereas the other provinces in the survey have Muslims as the majority group. The difference is reflected in the sample results. Ramadan is the Muslim fasting month and its exact date changes from year to year according to the lunar calendar. However, it usually falls in the period of August to November. Figure 4.5 shows the seasonal pattern of birth weight in North Sulawesi. Interestingly, the graph resembles Figures 4.1 and 4.4, which implies that the religious difference does not create a change in the seasonal pattern of birth weight in North Sulawesi.

Figure 4.5—Birth weight seasonality in North Sulawesi



Source: IMDG-1 (2010).
Note: CI = confidence interval.

Columns 1 and 2 of Table 4.4 show the effect of birth weight on the height-for-age Z-score among sampled children less than 30 months of age.[7] Columns 1 and 2 present noninstrumented and instrumented results, respectively. The interaction of birth month with province was used as an identifying instrument. First, note that the effect of birth weight is positive and significant in the instrumental variable (IV) estimation (column 2). Second, the parameter in the IV estimation is quite similar to that in the non-IV ordinary least squares (OLS) estimation (Column 1).

Table 4.4—Child (age 0–30 months) growth: Height and weight

	(1)	(2)	(3)	(4)
Dependent:	**Height-for-age Z-score**		**Weight-for-age Z-score**	
	No IV	**IV**	**No IV**	**IV**
Log birth weight	3.2520	3.2459	2.4102	2.1493
	(2.64)	(1.94)	(2.95)	(1.92)
Log birth weight × age	-0.1761	-0.0906	-0.0636	-0.0039
	(2.40)	(0.99)	(1.32)	(0.06)
Age in months	0.1417	0.0621	0.0183	-0.0399
	(1.57)	(0.57)	(0.33)	(0.55)
Female	0.2129	0.2805	0.4335	0.4686
	(0.92)	(1.18)	(2.74)	(3.04)
Birth year-fixed effects	Yes	Yes	Yes	Yes
Village-fixed effects	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman (chi-square)		4.87		4.34
p-value		0.08755		0.11407
R-square	0.3438	0.3308	0.3761	0.3676
Number of observations	366	366	372	372

Source: IMDG–1 (2007).
Notes: IV = instrumental variable. Numbers in parentheses are absolute t-values (columns 1 and 3 using robust standard errors). Log birth weight is treated as an endogenous variable.

Next the interaction of age and (log) birth weight is used to examine age-varying effects, which are treated as endogenous. Interestingly, the non-IV results show that age has a significant negative effect, suggesting that the importance of birth weight in determining child growth decreases as the child ages. If this term is not included, the IV estimate of the birth weight effect becomes much larger than that in the non-IV estimation, suggesting that there is a downward bias in the OLS analysis, along with a convergence in the process of child growth. These interpretations are mutually consistent. The IV estimates statistically differ from the non-IV estimates (p = 10 percent).

Columns 3 and 4 use the weight-for-age Z-score, which provides qualitatively similar results. First, birth weight has a significant positive effect on child weight in both the noninstrumented and instrumented estimations. This is not surprising: Birth weight represents a large portion of a child's weight at age 0–30 months. Second, the parameter in the IV estimation is smaller than that in the OLS estimation, suggesting that there is a diverging of child weight. Third, girls have a greater weight than boys, but no gender-related difference in child height is evident. However, the difference between the IV and non-IV estimates is marginally insignificant (p = 11 percent).

Next, the effects of birth weight on child schooling outcomes are examined (Table 4.5). Here the outcome variables are age at start of schooling and number of grades repeated in primary school. The age

[7] In children age 30–60 months, the relationship between birth weight and height is not clear. However, studies show that child nutrition and growth during ages 0–3 years critically determine schooling outcomes and labor market outcomes at adulthood.

range of the sample is 6 to 12 years. Like the analysis in Table 4.4, the estimation uses as instruments birth month indicators, interacted with village dummies. Columns 1 and 2 show the estimated effects on age at start of schooling without and with instruments, respectively. In Column 2, instrumental variables include birth month indicators interacted with village dummies. Although the instruments did not work effectively, both results confirm that an increase in birth weight significantly lowers age at start of schooling. Females tend to enter school at a younger age than males.

Table 4.5—Child (age 6–12 years) schooling: Age started and repetitions

	(1)	(2)	(3)	(4)
Dependent:	**Age started**		**Grades repeated**	
	No IV	**IV**	**No IV**	**IV**
Log birth weight	-0.2379 (2.17)	-0.2966 (2.24)	-0.1789 (1.66)	-0.2345 (2.14)
Log birth weight × female			0.1969 (1.67)	0.2979 (2.01)
Female	-0.0849 (1.93)	-0.0857 (1.90)	-0.3193 (2.30)	-0.4294 (2.57)
Birth year-fixed effects	Yes	Yes	Yes	Yes
Village-fixed effects	Yes	Yes	Yes	Yes
Durbin-Wu-Hausman (chi-square)		0.95		4.58
p-value		0.32966		0.10131
R-square	0.2636	0.2634	0.2489	0.2480
Number of observations	823	823	800	800

Source: IMDG–1 (2010).
Notes: IV = instrumental variable. Numbers in parentheses are absolute t-values (Columns 1 and 3 using robust standard errors). Log birth weight and its interaction with female indicator are treated as endogenous variables. In Column 2, instrumental variables include birth month indicators interacted with village dummies. In Column 4, instrumental variables include birth month indicators interacted with village dummies and female dummy, and the interactions of village and female dummies.

Columns 3 and 4 estimate the effects of birth weight on the number of grades repeated in primary school. In this analysis, it is important to control birth year, because this explains the number of years in school, which is correlated with grade repetitions. In Column 4, instrumental variables include birth month indicators interacted with village and female dummies, and the interactions of village and female dummies. The instrumental variable estimation results are marginally supported (p = 10 percent). Females not only tend to repeat grades less, but also alter the effect of birth weight. Among males, an increase in birth weight significantly reduces the number of grades repeated. This effect does not exist among girls (the first two estimates are almost canceled out). The conclusion is that combined with the results on age at start of schooling, greater birth weight leads to higher grade attainment in elementary school.

Overall there seems to be a female advantage in schooling investments and outcomes in this empirical setting. An increase in birth weight helps both boys and girls start schooling at a younger age, although girls tend to start schooling earlier than boys. Once schooling starts, girls tend to advance in grade faster than boys. Only among boys, however, greater birth weight helps reduce the number of repetitions.

5. CONCLUSION

The present analysis demonstrates the importance of natural and human factors in determining child growth and health in Indonesia. Seasonality in birth weight, potentially caused by the agricultural production cycle (rainfall patterns) and social norms, significantly affects the height-for-age and weight-for-age Z-scores and performance at primary school. The findings not only pertain to children's human capital in the short run, but also have implications for their long-term human capital.

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